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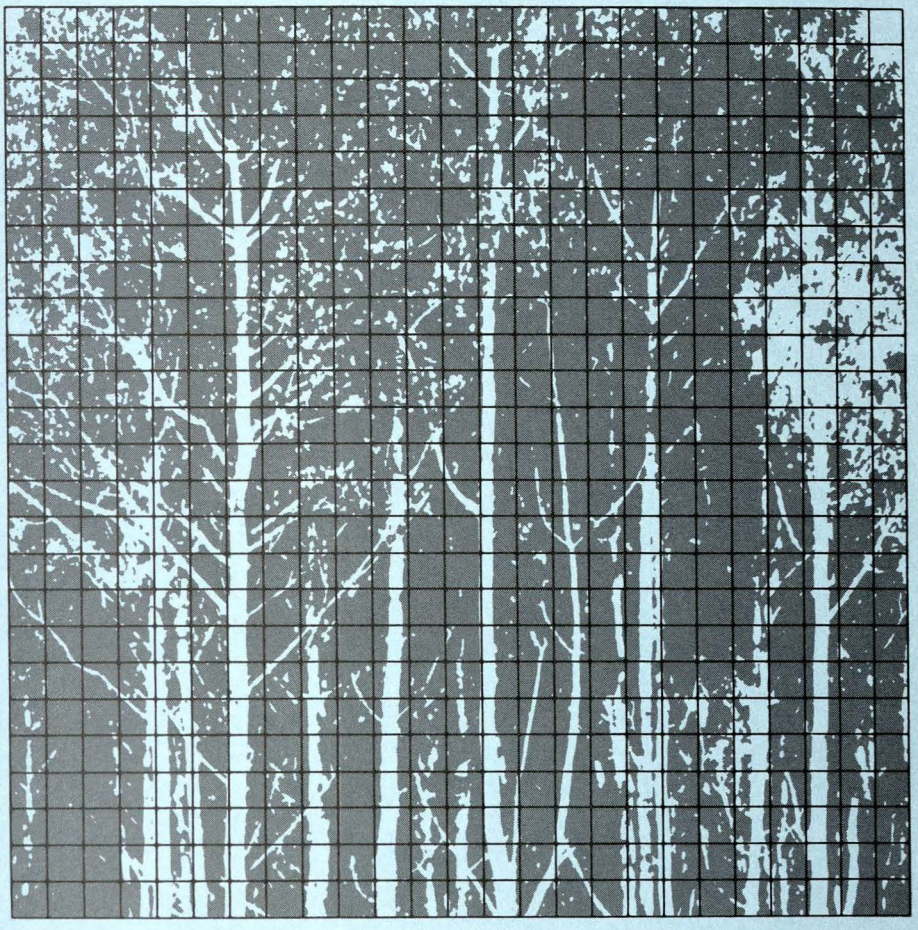

Evaluating stocking in **upland hardwood forests** using metric measurements

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WE GOOFED!

On Research Paper NC-187 "Evaluating Stocking in Upland Hardwood Forests Using Metric Measurements"

Page 2: Table 1 column headings <u>should</u> read--

ft^2/a m^2/ha m^2/ha ft^2/a

Page 4: End of first paragraph <u>should</u> read--

. . . factors presented below.

Sorry about that!

EVALUATING STOCKING IN UPLAND HARDWOOD FORESTS USING METRIC MEASUREMENTS

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Stocking standards have been established for upland hardwood stands. The standards define the range of stocking within which the amount of space available for tree growth is fully utilized. The methods used to develop the stocking standards (Gingrich 1964, 1967) and the use of these standards in making stand prescriptions have been published (Roach and Gingrich 1968, Sander 1977) and have been widely adopted for field use.

Stocking is related to basal area per acre, number of trees per acre, and diameter of the tree of average basal area. These relations have been depicted in the form of a stocking chart (fig. 1). However, the data needed to interpret stocking percent and average tree diameter are based on measurements made in the English system.

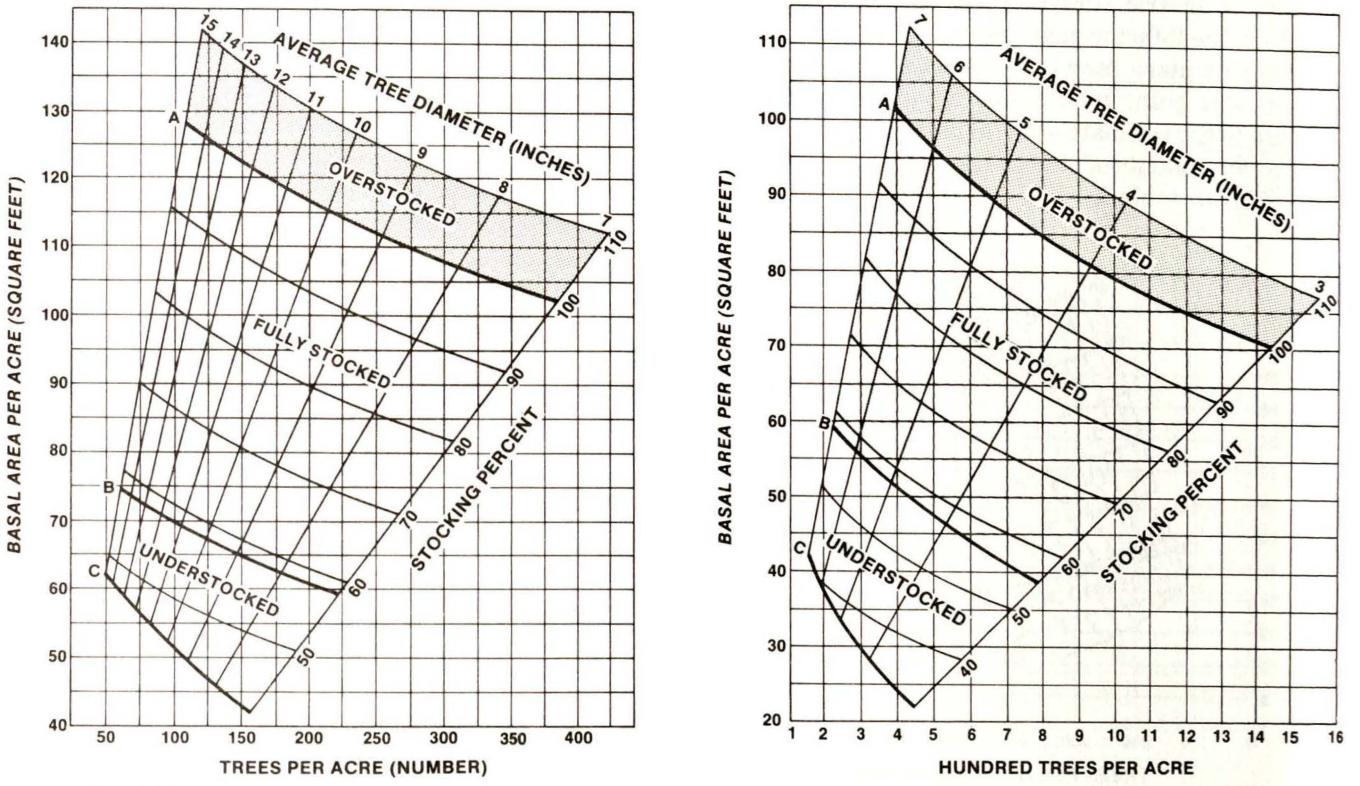


Figure 1.—*Relations of basal area, number of trees, and average tree diameter to stocking percent for upland hardwood forests of average uniformity. Tree diameter range 7-15 inches (left), 3-7 inches (right). The area between curves A and B indicates the range of stocking where trees can fully utilize the growing space. Curve C shows the lower limit of stocking necessary to reach the B level in 10 years on average sites. (Average tree diameter is the diameter of the tree of average basal area.) (From Gingrich 1967).*

The purpose of this paper is to provide the information necessary to evaluate stocking when measurements have been made in the metric system and to provide some pertinent conversion factors.

EVALUATING STOCKING

The basic data needed to evaluate stand stocking are basal area and tree count. Stocking percent and average stand diameter are determined from figure 2 using these two data items. Basal area and the number of trees can be estimated by using the method suggested by Roach and Gingrich (1968) but modified to accomodate metric measurements.

BASAL AREA

The use of an angle gage or wedge prism makes the determination of basal area in the field by the point sample technique easy and quick. The 10-factor gage has proved well suited for use with the central hardwoods and is widely used in this type. The approximate metric equivalent of the 10-factor gage (ft^2/A) is the 2-factor gage (m^2/ha). This gage is calibrated in square meters per hectare, so each tree tallied at a point contributes 2 square meters per hectare to the estimate of basal area per hectare. The metric equivalents of other basal area factors (BAFs) are given in table 1.

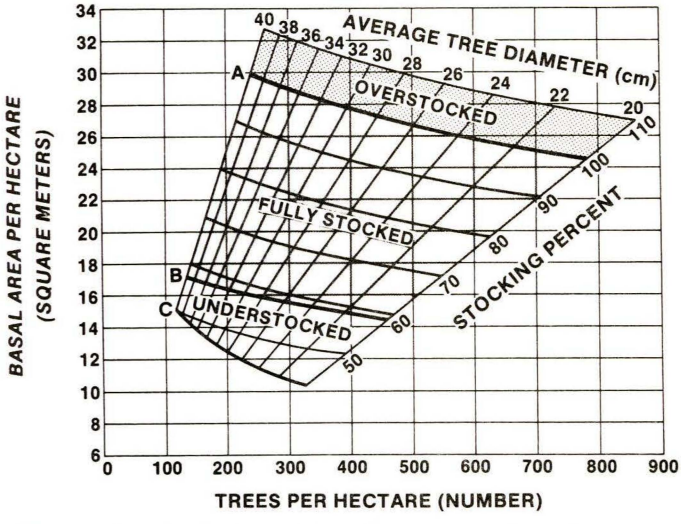
Table 1.— *Basal area factor (BAF) conversions*

BAF	BAF	BAF	BAF
ft^2/a	m^2/ha	ft^2/a	m^2/ha
5	1.15	1	4.36
10	2.30	2	8.71
15	3.44	3	13.07
20	4.59	4	17.42
25	5.75	5	21.78
30	6.89	7	30.49

TREE COUNT

A tree count can be made on a plot of fixed radius whose center is coincident with the point of the point sample. Normally a 1/20th-acre plot is recommended for the tree count in the English system. In the metric system, a 1/50th hectare plot whose radius is 7.98 meters approximates 1/20th acre. Trees lying within plot boundaries are counted and the total multiplied by 50 in order to put the number of trees counted on a per hectare basis. Thus, the number of trees in the metric system is expressed as the number of trees per hectare.

An alternative method for obtaining the tree count is to use the conversion factors for the number of trees per hectare based upon the sizes of trees tallied using



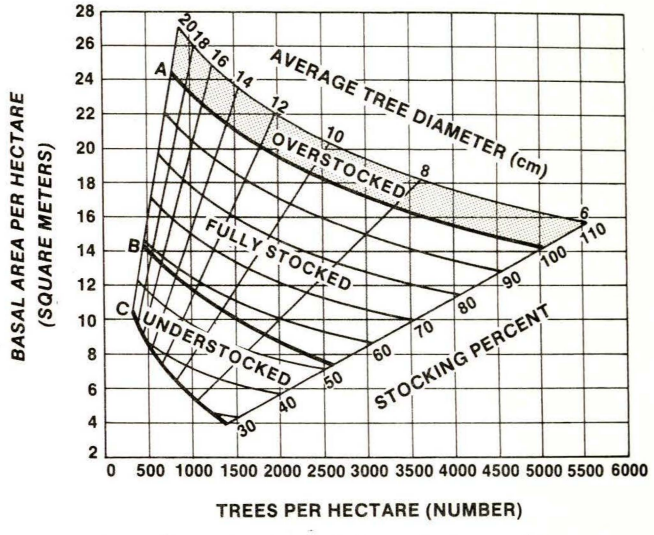


Figure 2.— *Relation of basal area, number of trees, and average tree diameter in metric units to stocking percentage for upland central hardwoods. Tree diameter range 20-40 cm (a), and 6-20 cm (b). The area between curves A and B on both charts indicates the range of stocking where trees can fully utilize the growing space. Curve C shows the lower limit of stocking necessary to reach the B level in 10 years on average sites. (Average tree diameter is the diameter of the tree of average basal area.)*

the angle gage. The per hectare conversion factors for BAF 2 (m^2/ha) are given in the tabulation below.[1]

Diameter (cm)	Number of trees
2	6366
6	707
10	255
14	130
18	79
22	53
26	38
30	28
34	22
38	18
42	14
46	12
50	10.2
54	8.7
58	7.6
62	6.6
66	5.8
70	5.2
74	4.7
78	4.2

If two 18 cm, two 30 cm, four 50 cm, and two 62 cm trees were tallied at a point, then $2 \times 79 + 2 \times 28 + 4 \times 10.2 + 2 \times 6.6 = 268$ trees/ha (the basal area would be 2×10 trees $= 20$ m^2/ha).

THE TALLY

A tally such as proposed by Roach and Gingrich (1968; fig. 22, p. 24) can be modified for use with metric measurements. A 2-factor prism is used to estimate basal area in square meters per hectare (m^2/ha) at 10 point samples and the number of trees per hectare is estimated by tree counts on 1/50th-hectare plots. An example of a tally using metric measurements is presented in table 2. Stocking percent and average stand diameter are determined from figure 2 using the estimates of basal area and number of trees obtained from the data collected in table 2.

[1] *The tabulation is based on the following equation: Per-hectare conversion factor = BAF/(7.85398 × $10^{-5}D^2$) where BAF = 2.*

Table 2.— *Sample tally sheet*

Sample point number	Mature Timber	Basal area tally: Sawtimber AGS[1]	Sawtimber UGS[2]	Poletimber AGS	Poletimber UGS	Small trees AGS	Small trees UGS	Cull	Tree count: No. trees per 1/50-hectare plot
1		2	1	2	2			1	10
2		6		3	2		1		13
3		1	2	5	1			2	10
4		3	1	2	4		1		9
5		6		1		1		2	11
6		2	2	2	1		2		12
7		4		1	3		1		10
8		3	2		2	2		2	9
9		5	1	1	3	1	2	1	14
10		2	1	3	2		1		12
Total	0	34	10	20	20	4	8	8	110
Per ha[3]		6.8	2.0	4.0	4.0	.8	1.6	1.6	110 × 5 = 550

Basal area: AGS 11.6 Total 20.8
Number of trees/ha: 550
Stocking percent: 83
Average tree diameter: 22 cm

[1] Acceptable Growing Stock.
[2] Unacceptable Growing Stock.
[3] Obtained by multiplying 2 times total and dividing by 10 (number of points), e.g., $2 \times 34 = 68$ $68/10 = 6.8$. General formula is $\frac{\text{BAF x tree count}}{\text{No. of points}}$.

STOCKING PERCENT PARAMETER CONVERSIONS

Parameter estimates made from data collected in either the English or metric system can be converted to the other system using the conversion factors presented on page xx.

Example 1. Metric to English
Given:
Percent stocking = 85
Number of trees/hectare = 530
Basal area, square meters per hectare = 22
Average tree diameter, cm = 23.0
English equivalent:
Percent stocking = 85
Number of trees/acre = 0.4047 × 530 = 214
Basal area, square feet per acre = 4.356 × 22 = 96
Average tree diameter, inches = 0.3937 × 23.0 = 9.1

Example 2. English to Metric
Given:
Percent stocking = 90
Number of trees per acre = 275
Basal area, square feet per acre = 96
Average tree diameter, inches = 8.0
Metric equivalent:
Percent stocking = 90
Number of trees per hectare = 2.471 × 275 = 680
Basal area, square meters per hectare = 0.22957 × 96 = 22
Average tree diameter, cm = 2.54 × 8.0 = 20.3

English-Metric Conversion Factors

Metric to English:
Basal area per acre (sq. ft.) = 4.356 × basal area per hectare (m^2)
Trees per acre = 0.4047 × trees per hectare
Average tree diameter (inches) = 0.3937 × average tree diameter (cm)
Tree basal area (sq. ft.) = .0008454 × d.b.h.^{2} (cm)
Square feet = 10.764 × square meters
Feet = 0.3048 × meters
Acres = 2.471 × hectares

English to Metric:
Basal area per hectare (sq. meters) = 0.22957 × basal area per acre ($ft.^2$)
Trees per hectare = 2.471 × trees per acre
Average tree diameter (cm) = 2.54 × average tree diameter (in.)
Tree basal area (sq. meters) = .0005067 × d.b.h.^{2} (in.)
Square meters = 0.0929 × square feet
Meters = 3.28 × feet
Hectares = 0.4047 × acres

TREE AREA EQUATION

Gingrich's (1967) original tree area equation used to compute the stocking-density criteria expressed tree area in terms of mil-acres. This equation has the form:

Tree area (mil-acres) = $aN + b\,\Sigma D + c\,\Sigma D^2$, where N = number of trees per acre and D = tree diameter in inches. Solving this equation (given the appropriate constants a, b, and c) for N = 1 and D = any given diameter, defines the minimum tree area requirements for that size tree. Thus a stand having 1,000 mil-acres of tree area per acre was considered to be 100 percent stocked (A-Level).

In the metric system tree area is expressed in ares. One are equals 100 square meters and therefore 100 ares equals one hectare (10,000 square meters). A stand having 100 ares of tree area per hectare is considered to be 100 percent stocked. N is the number of trees per hectare and D is measured in centimeters. The metric stocking equation is:

Tree area (ares) = $(-2.0518N + 2.7053\,\Sigma D + 0.19884\,\Sigma D^2)/1000$. (Stocking percent)

Minimum tree area requirements expressed in ares (stocking percent) for individual trees of varying diameters are given in the tabulation below. The metric equation expressing the maximum amount of area that trees can use (B-Level) is:

Tree area (ares) = $(7.0820 + 3.2662\,\Sigma D + 0.37636\,\Sigma D^2)/1000$.

D.b.h. (cm)	Tree area (ares)	D.b.h. (cm)	Tree area (ares)
6	0.0213	40	0.4243
8	0.0323	42	0.4623
10	0.0449	44	0.5019
12	0.0590	46	0.5431
14	0.0748	48	0.5859
16	0.0921	50	0.6303
18	0.1111	52	0.6763
20	0.1316	54	0.7239
22	0.1537	56	0.7730
24	0.1774	58	0.8238
26	0.2027	60	0.8761
28	0.2296	62	0.9300
30	0.2581	64	0.9855
32	0.2881	66	1.0427
34	0.3198	68	1.1013
36	0.3530	70	1.1616
38	0.3879	72	1.2235

SUMMARY

In an effort to carry out our Nation's commitment to adopt the metric standard, this publication makes available information necessary to evaluate stocking in upland hardwood forests when stocking variables are based on metric measurements. Metric-English conversions are presented so that comparisons can be made between stocking variables obtained using either measurement system.

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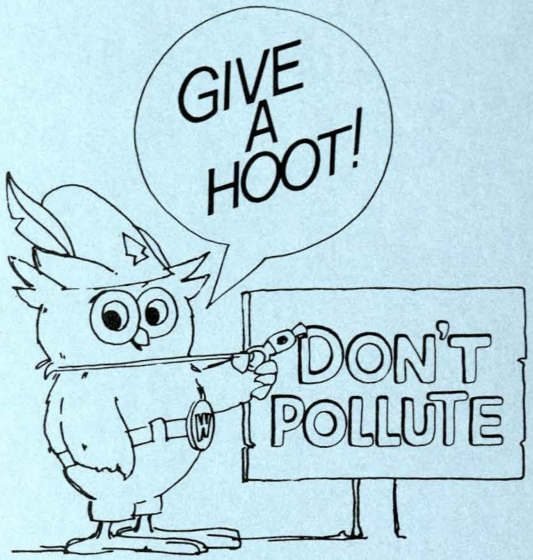
Allows stocking percent in upland forests as developed by Gingrich (1964, 1967) to be calculated when tree and stand variables are measured in the metric system.

KEY WORDS: Metric stocking percent, metric stocking conversion factors, metric tree area equation, tree area requirements, and oak-hickory forests.



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